



**SPC Benchmark 2/Energy™ (SPC-2/E™)**  
**SPC Benchmark 2C/Energy™ (SPC-2C/E™)**

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## SPC-1/E, SPC-1C/E Overview

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- SPC Benchmark 1C/Energy™ (*SPC-1C/E™*) is an extension to the first storage component benchmark, SPC Benchmark 1C™ (*SPC-1C™*).
- SPC-1C/E was publicly announced on June 3, 2009.
- SPC-1C/E consists of the complete set of SPC-1C performance measurements and reporting, combined with the measurement and reporting of energy use.



## SPC-1/E, SPC-1C/E Overview

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- SPC Benchmark 1/Energy™ (*SPC-1/E™*) is an extension to the first industry standard storage benchmark, SPC Benchmark 1™ (*SPC-1™*).
- SPC-1/E was publicly announced on October 13, 2009.
- SPC-1/E consists of the complete set of SPC-1 performance measurements and reporting, combined with the measurement and reporting of energy use.



## SPC-2/E and SPC-2C/E

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- The SPC-2/E and SPC-2C/E energy extensions were announced on October 20, 2011.
- SPC-2/E and SPC-2C/E extend the SPC Energy Extensions to the sequential workloads of SPC-2 and SPC-2C.
- IBM and Seagate were the first SPC member companies to submit results at that time.
  - [IBM XIV® Storage System Gen3](#)
  - [Seagate Constellation.2™ \(ST91000640SS\)](#)



## SPC-2, SPC-2C Introduction

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- SPC-2 consists of three distinct workloads to demonstrate storage performance for application types that require large-scale, sequential movement of data.
  - Large File Processing
  - Large Database Query
  - Video on Demand Delivery
- These application types are characterized predominately by large I/O organized into one or more concurrent sequential patterns.



## SPC-2, SPC-2C Introduction

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- ❑ **Large File Processing (LFP):** Typical of applications in a wide range of fields that require simple sequential processing of one or more large files such as scientific computing and large-scale financial processing.
- ❑ **Large Database Query (LDQ):** A class of applications that involve scans or joins of large relational tables, such as those performed for data mining or business intelligence.
- ❑ **Video on Demand Delivery (VOD):** Designed for applications that provide individualized video entertainment to a community of subscribers by drawing from a digital film library.



## SPC-2, SPC-2C Introduction

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- SPC-2C is a component-level benchmark that is applicable to products such as storage devices, HBAs, intelligent enclosures, and storage software.
- SPC-2C consists of the same three, distinct workloads as SPC-2,
  - Large File Processing (LFP)
  - Large Database Query (LDQ)
  - Video on Demand Delivery (VOD)



## SPC-2, SPC-2C Introduction

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- An SPC-2C configuration consists of one or more HBAs/controllers and one of the following storage device configurations:
  - One, two or four storage devices in a “standalone” configuration. An external enclosure may be used but only to provide power and/or connectivity.
  - A “Small Storage Configuration” with a maximum of forty-eight storage devices in no larger than a 4U enclosure profile.



## SPC-2/E, SPC-2C/E Introduction

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- SPC-2C/E is only applicable to Small Storage Subsystems not the 1/2/4 Storage Device configurations of SPC-2C.
- SPC-2/E expands measurement to larger, more complex storage configurations.



## SPC-2/E, SPC-2C/E Introduction

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- SPC-2/E and SPC-2C/E expands the SPC's portfolio of storage benchmarks.
  - Performance, price-performance (*including support/maintenance*), and power consumption/energy use.
  - SPC-1/E, SPC-1C/E (*OLTP*) and SPC-2/E, SPC-2C/E (*sequential*) address a significant portion of the application 'space'.
  - SPC-1C/E, SPC-2C/E (*component level*) and SPC-1/E, SPC-2/E (*complex configuration*) address the spectrum of storage products.



## SPC-2/E, SPC-2C/E Introduction

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- In addition to the “core” SPC-2 / SPC-2C performance measurement and reporting requirements, the two energy extensions define:
  - Configuration and instrumentation requirements for energy usage measurement
  - Execution requirements for application idle state measurements and the transition into active (*performance*) state measurements
  - Data collection requirements for energy use measurements
  - Expanded disclosure and audit requirements



## SPC-2/E, SPC-2C/E Introduction

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- The storage configuration's energy use is measured and reported.
  - Measurements are taken during both application idle and active states of the benchmark execution.
  - Multiple application idle phases are allowed.
  - The active (*performance*) state consists of the SPC-2 or SPC-2C Tests.
- SPC-2/E and SPC-2C/E energy use results cannot be reported without the corresponding performance results.



## SPC-2/E, SPC-2C/E Introduction

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- SPC-2/E or SPC-2C/E execution profile:
  - A 10 minute pre-idle phase at the maximum Large File Processing (*read/write*) sequential throughput.
  - An application idle phase lasting at least 30 minutes with one or more distinct phases.
  - Each application idle phase may be preceded by an optional transition period not to exceed 3 minutes.
  - A second 10 minute post-idle phase at 25% of the the maximum Large File Processing (*read/write*) sequential throughput.
  - Execution of the complete SPC-2 or SPC-2C Tests: LFP, LDQ and VOD.

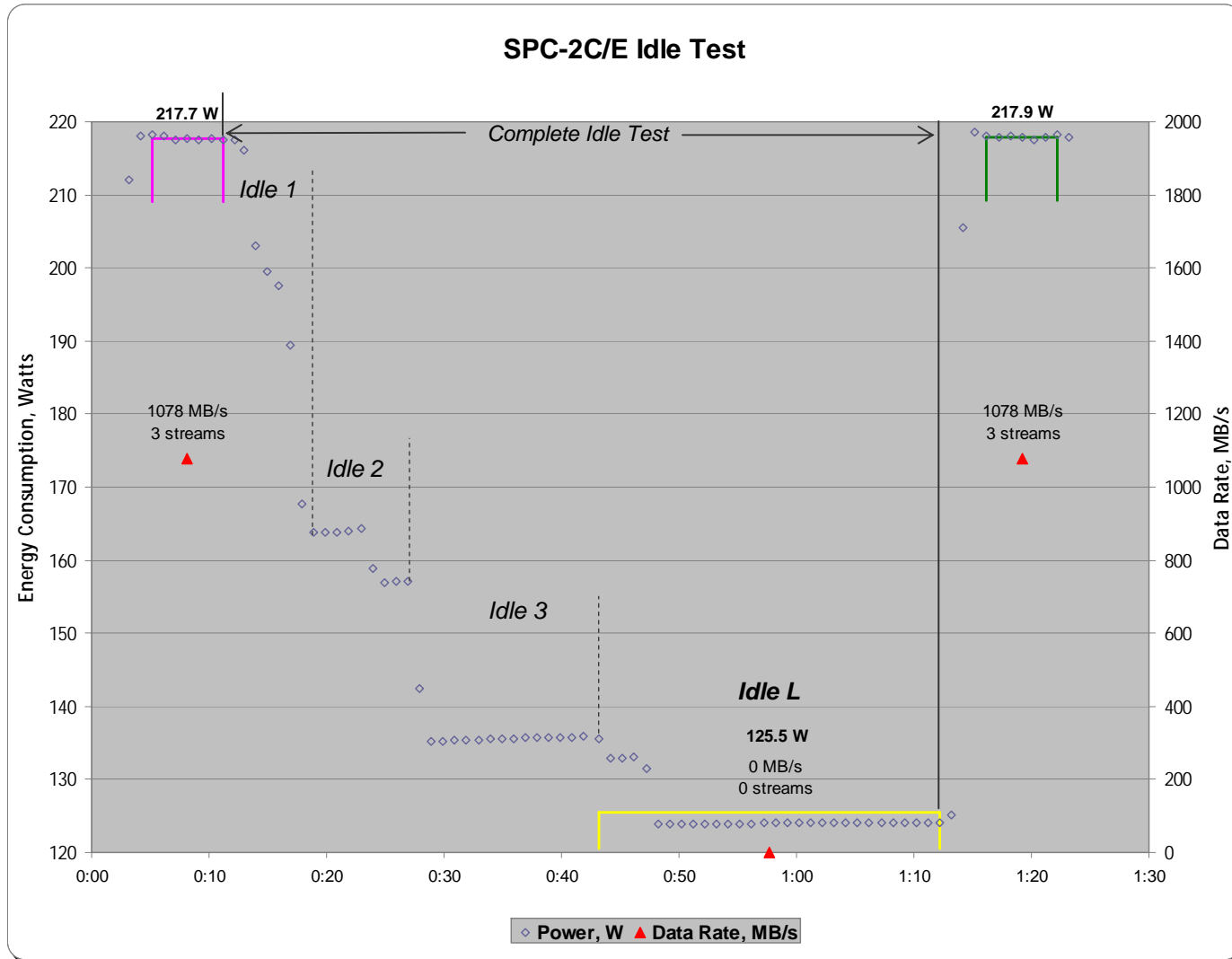


## SPC-2/E, SPC-2C/E Introduction

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- SPC-2/E and SPC-2C/E idle phases:
  - More than one idle phase is allowed as long as transitions between idle phases do not require manual intervention.  
*Idle Phase 0, Idle Phase 1...Idle Phase L-1, Idle Phase L*
  - Idle Phase 0 thru Idle Phase L-1 must have the same duration, selected by the Test Sponsor, up to a maximum of 10 minutes.
  - Idle Phase L (“deepest” idle state) duration is selected by the Test Sponsor with a minimum of 30 minutes.
  - The simplest Idle Test consists of a single idle phase with a minimum duration of 30 minutes.

# SPC-2C/E Idle Test Chart





## SPC-2/E, SPC-2C/E Introduction

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- The SPC-2/E and SPC-2C/E required tables and charts both list and illustrate storage performance and energy use for each performance test.
- SPC-2/E and SPC-2C/E Reported Data includes multiple energy use metrics:
  - Across several selected environments
  - Taking into account hourly variations in I/O load
- This reported data will allow an estimate of average annual energy use.



## SPC-2/E, SPC-2C/E Introduction

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- The SPC-2/E and SPC-2C/E required charts illustrate the measured performance and associated energy required for each SPC-2/E, SPC-2C/E Test Run.
- Each Large File Processing (LFP) and Large Database Query (LDQ) test sequence consists of 5 Test Runs at the following load levels:
  - Maximum streams of sequential I/O requests
  - 50% of the maximum
  - 25% of the maximum
  - 12.5% of the maximum
  - 1 stream of sequential I/O requests



## SPC-2/E, SPC-2C/E Introduction

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- The Video on Demand Delivery (VOD) Test consists of the maximum number of sequential streams that can be supported without encountering a “late” response to an I/O request.
  - Each stream represents a user viewing video content.
  - A “late” response represents a “dropped” video frame.
  
- The Idle Test consists of no application I/O presented to the configuration.



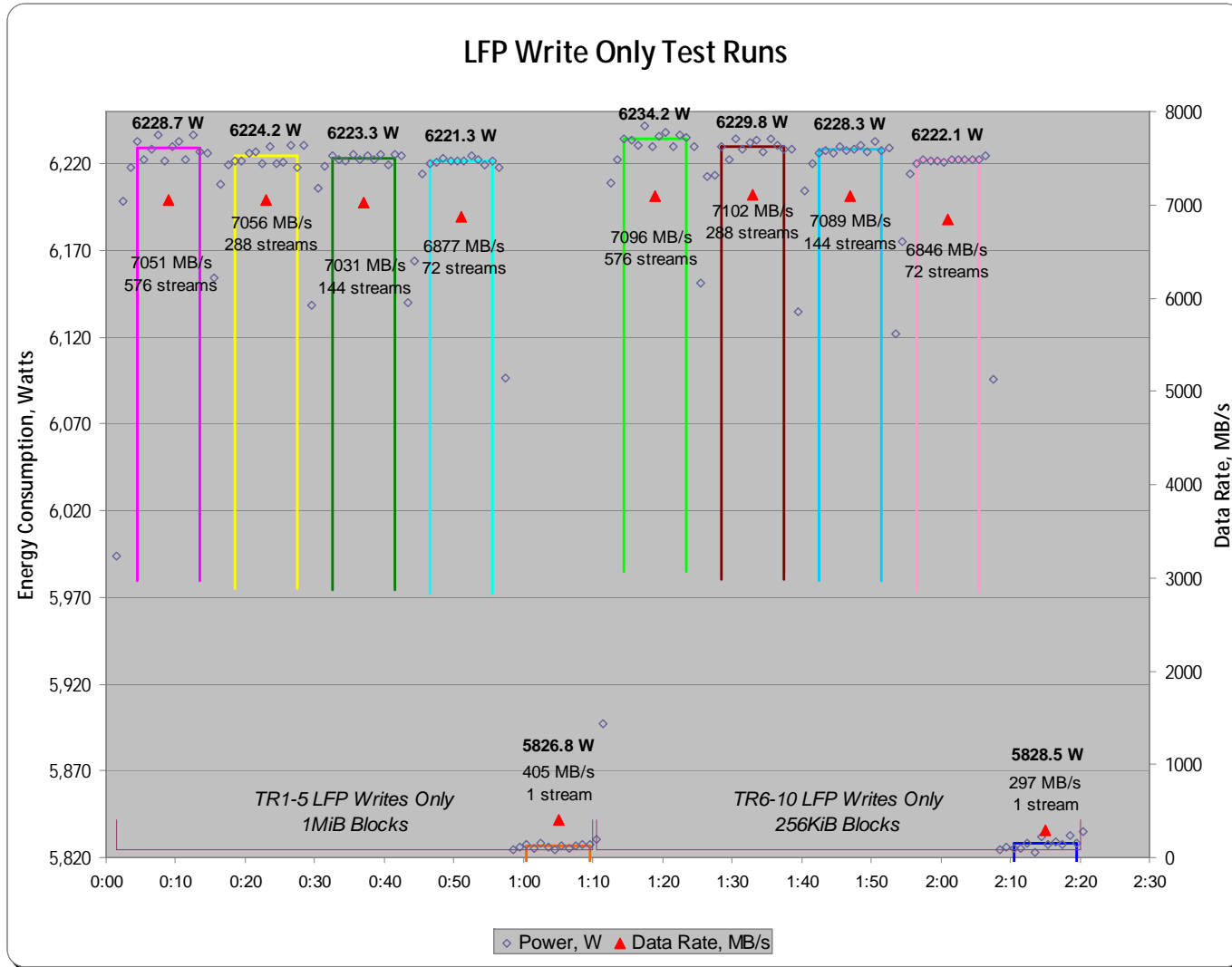
# SPC-2/E, SPC-2C/E Introduction

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- The SPC-2/E and SPC-2C/E required charts:
  - Idle Test: *Pre-Idle, Idle, and Post-Idle*
  - Large File Processing (LFP)
    - LFP Write-Only, 1024 and 256 KiB Transfer
    - LFP Read-Write, 1024 and 256 KiB Transfer
    - LFP Read-Only, 1024 and 256 KiB Transfer
  - Large Database Query (LDQ)
    - LDQ 1024 KiB Transfer, 4 and 1 outstanding I/O requests
    - LDQ 64 KiB Transfer, 4 and 1 outstanding I/O requests
  - Video on Demand Delivery (VOD)

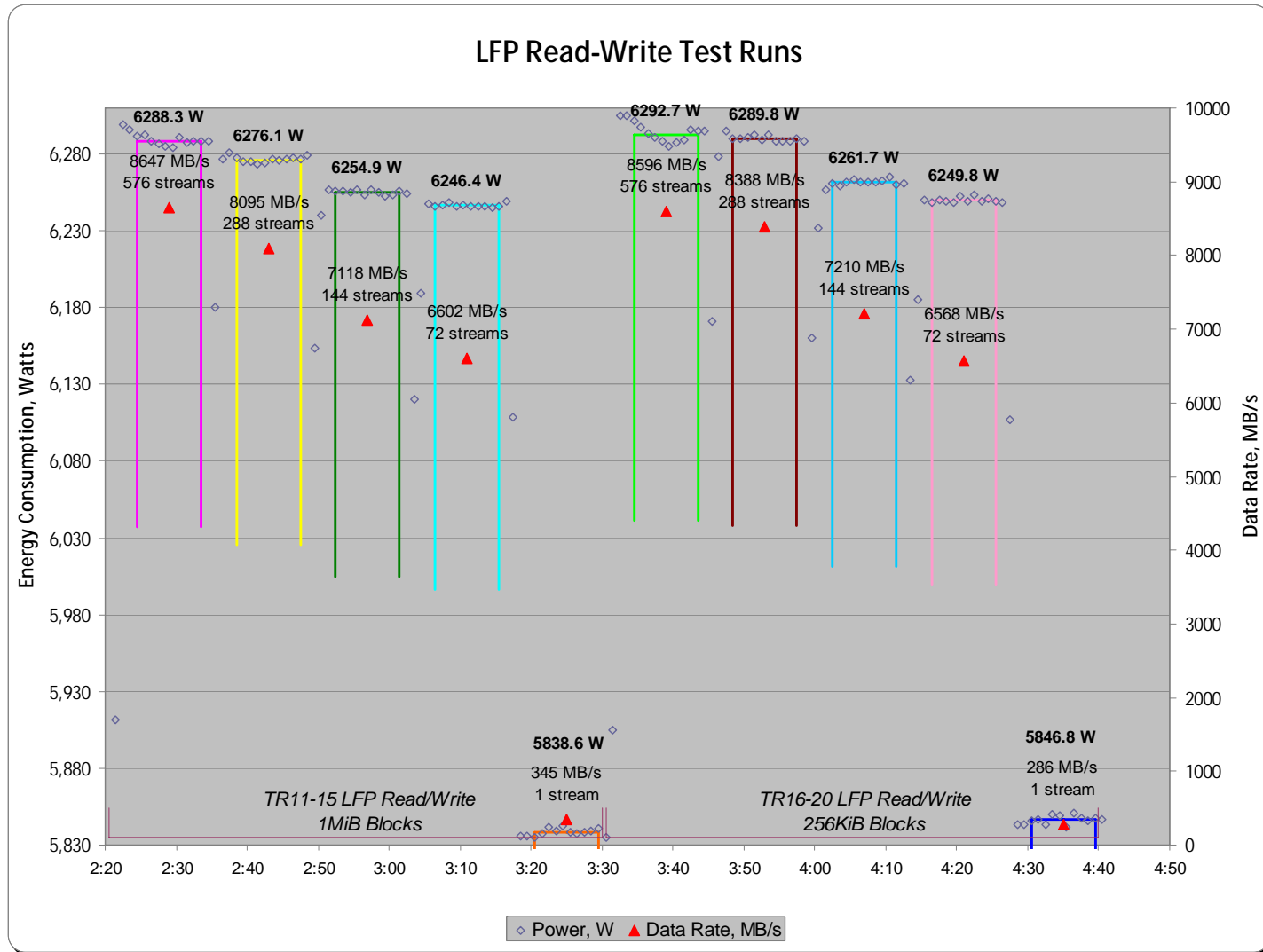


# SPC-2/E LFP Write-Only Test Runs



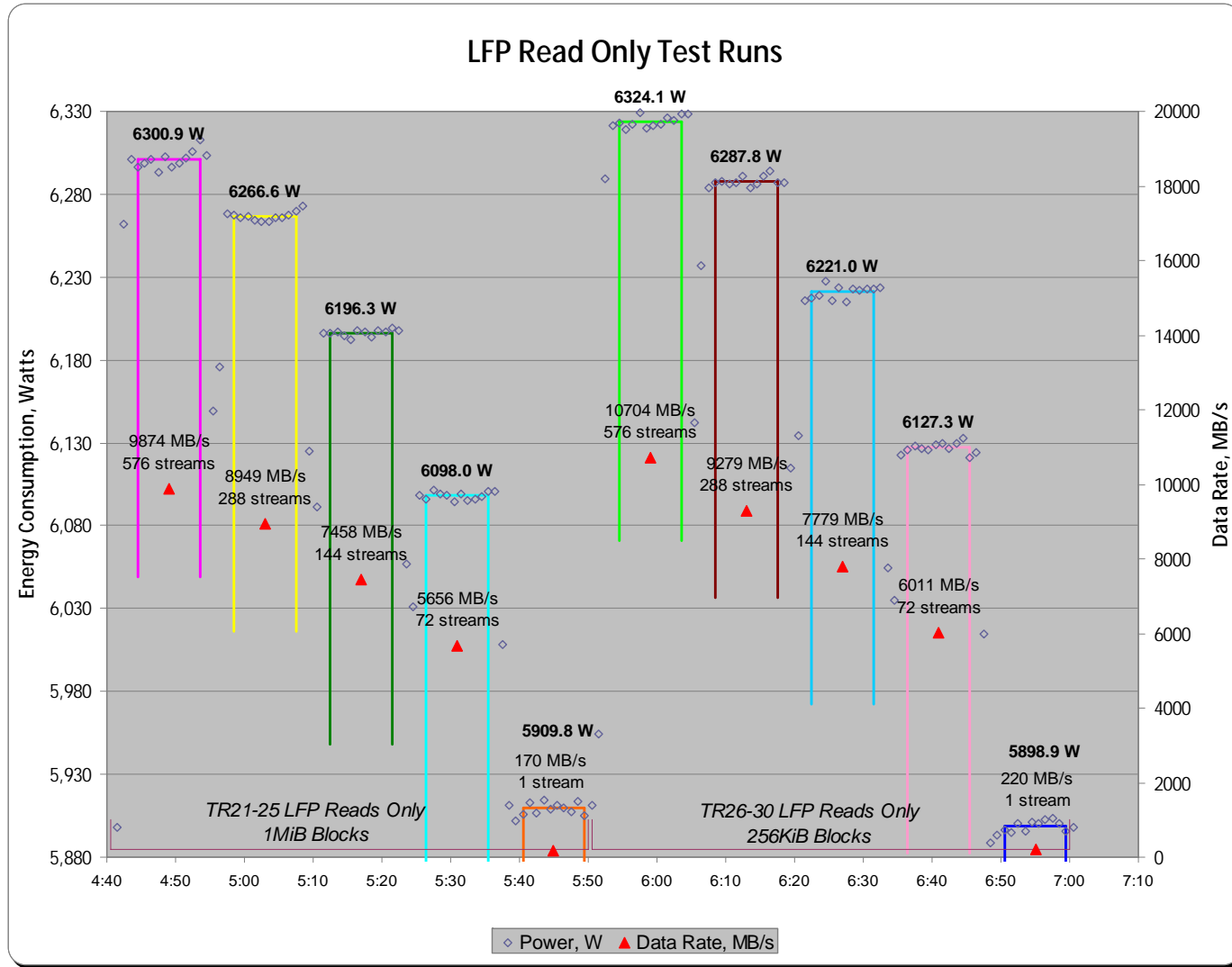


# SPC-2/E LFP Read-Write Test Runs



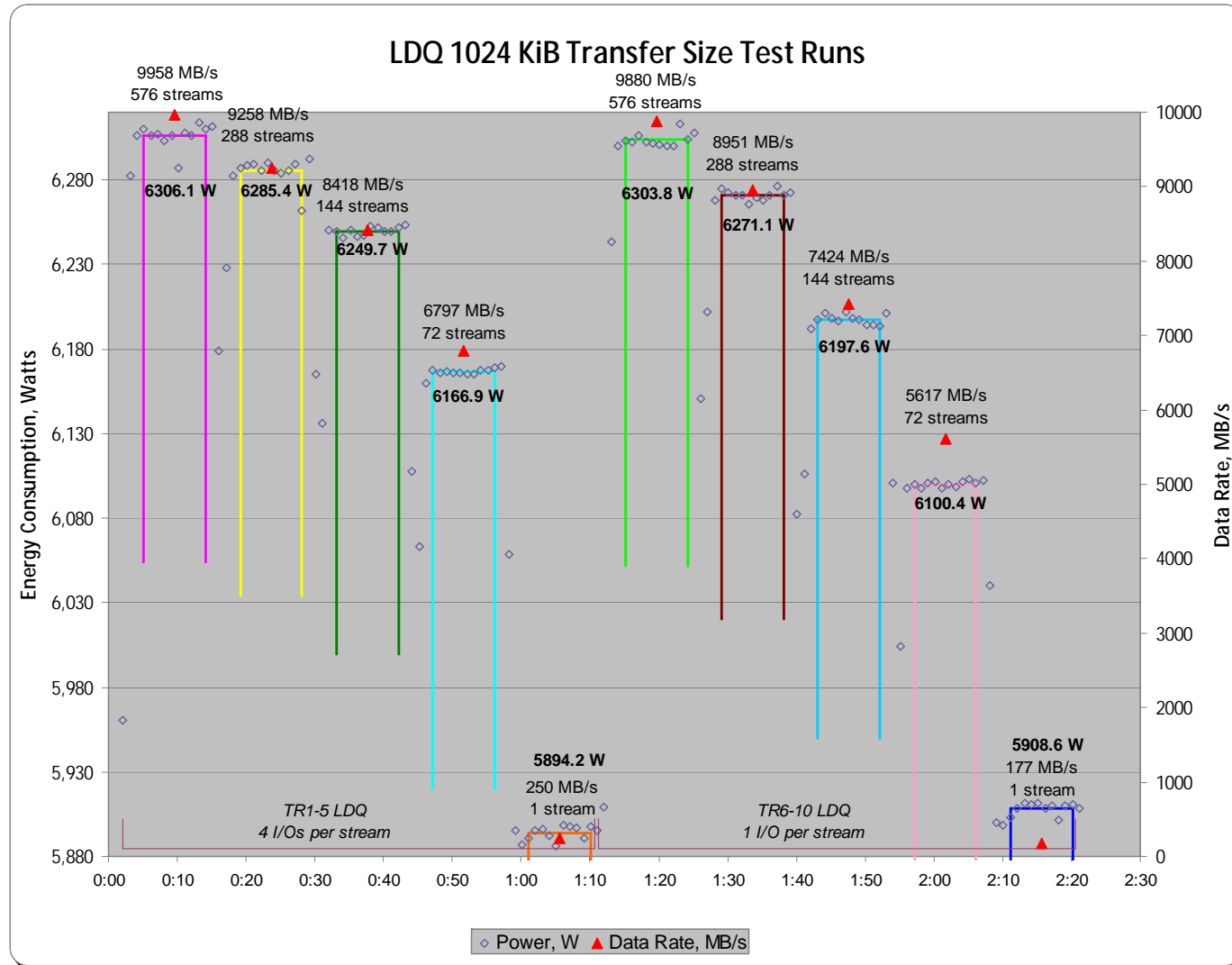


# SPC-2/E LFP Read-Only Test Runs

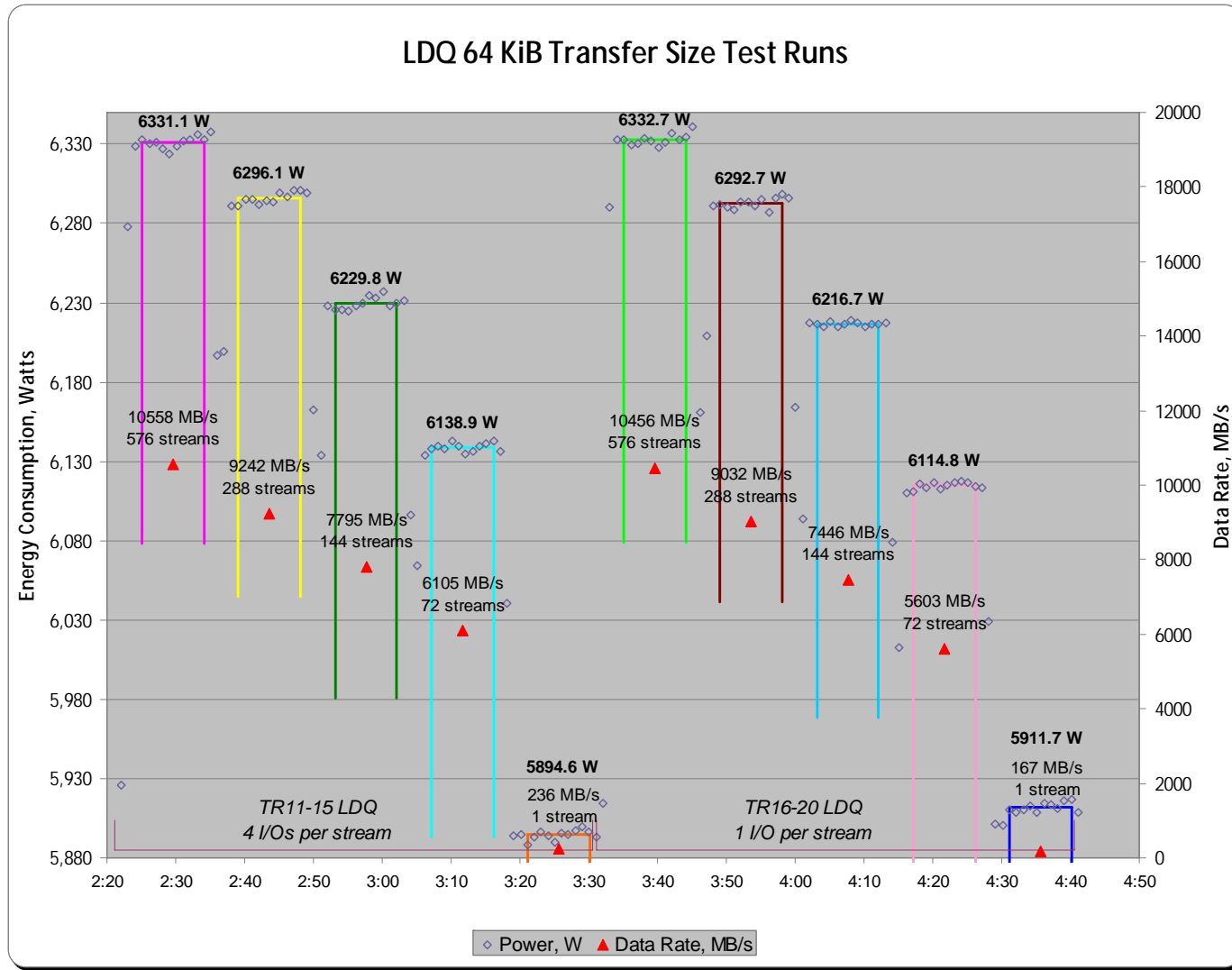




# SPC-2/E LDQ 1024 KiB Test Runs

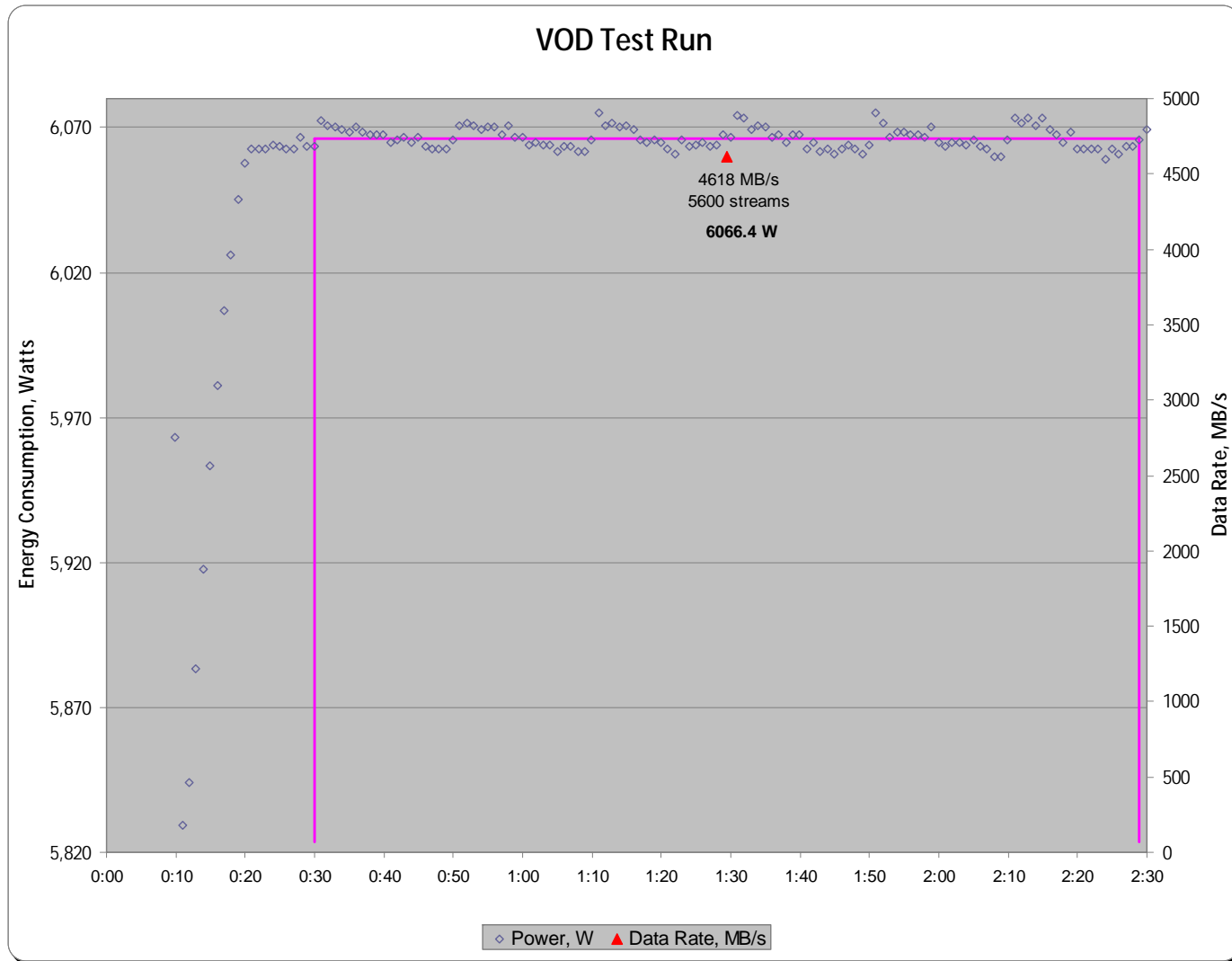


# SPC-2/E LDQ 64 KiB Test Runs





# SPC-2/E VOD Test Run





## SPC-2/E, SPC-2C/E Introduction

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- The SPC-2/E and SPC-2C/E Reported Data tables:
  - [Composite](#): a combination of all three workloads
  - [Large File Processing \(LFP\)](#)
  - [Large Database Query \(LDQ\)](#)
  - [Video on Demand Delivery \(VOD\)](#)



# SPC-2/E, SPC-2C/E Introduction

- An example of SPC-2/E Composite Reported Data:
  - Composite data that combines LFP, LDQ and VOD
  - An identical table is produced for each of the three workloads
  - SPC-2C/E Reported Data is in an identical format.

**Power Environment**

Average RMS Voltage:

209.83

Average Power Factor:

0.978

	Usage Profile			Nominal			
	Hours of Use per Day			Power watts	Traffic MBPS	Ratio MBPS/w	Heat BTU/hr
	Heavy	Moderate	Idle				
Low Daily Usage:	0	8	16	6049.33	2185.53	0.36	20,640.91
Medium Daily Usage:	4	14	6	6134.88	5129.80	0.84	20,932.84
High Daily Usage:	18	6	0	6209.13	7512.21	1.21	21,186.16

**Composite Metrics:**

6,131.11    4,942.51    0.81

Annual Energy Use, kWh:

53,708.55

Energy Cost, \$/kWh:

\$ 0.12

Annual Energy Cost, \$:

\$ 6,445.03



# SPC-2/E, SPC-2C/E Introduction

## □ SPC-2/E and SPC-2C/E Reported Data definitions:

Average RMS Voltage: 209.83      Average Power Factor: 0.978

	Usage Profile			Nominal			
	Hours of Use per Day			Power watts	Traffic MBPS	Ratio MBPS/w	Heat BTU/hr
	Heavy	Moderate	Idle				
Low Daily Usage:	0	8	16	6049.33	2185.53	0.36	20,640.91
Medium Daily Usage:	4	14	6	6134.88	5129.80	0.84	20,932.84
High Daily Usage:	18	6	0	6209.13	7512.21	1.21	21,186.16

Composite Metrics: 6,131.11    4,942.51    0.81

Annual Energy Use, kWh: 53,708.55      Annual Energy Cost, \$: \$ 6,445.03

Energy Cost, \$/kWh: \$ 0.12

**HEAVY** SPC-2 Workload: 6,220.98W at a data rate of 7,830.75 MB/s.

**MODERATE** SPC-2 Workload: 6,173.58W at a data rate of 6,556.58 MB/s

**IDLE** SPC-2 Workload: 5,987.20W at data rate of zero (0).

**AVERAGE RMS VOLTAGE:** The average supply voltage applied to the Tested Storage Product (TSP) as measured during the Measurement Intervals of the SPC-2 Tests.

**AVERAGE POWER FACTOR:** The ratio of average real power, in watts, to the average apparent power, in volt-amps flowing into the Tested Storage Product (TSP) during the Measurement Intervals of the SPC-2 Tests.



# SPC-2/E, SPC-2C/E Introduction

## □ SPC-2/E and SPC-2C/E Reported Data definitions:

### Power Environment

Average RMS Voltage:  Average Power Factor:

	Usage Profile			Nominal			
	Hours of Use per Day			Power watts	Traffic MBPS	Ratio MBPS/w	Heat BTU/hr
	Heavy	Moderate	Idle				
Low Daily Usage:	0	8	16	6049.33	2185.53	0.36	20,640.91
Medium Daily Usage:	4	14	6	6134.88	5129.80	0.84	20,932.84
High Daily Usage:	18	6	0	6209.13	7512.21	1.21	21,186.16

Composite Metrics:		<input type="text" value="6,131.11"/>	<input type="text" value="4,942.51"/>	<input type="text" value="0.81"/>
Annual Energy Use, kWh:	53,708.55			
Energy Cost, \$/kWh:	\$ 0.12	Annual Energy Cost, \$:	<input type="text" value="\$ 6,445.03"/>	

**NOMINAL POWER, W:** The average power consumption over the course of a day (24 hours), taking into account hourly load variations.

**NOMINAL TRAFFIC, MBPS:** The average data rate over the course of a day (24 hours), taking into account hourly load variations.

**NOMINAL MBPS/W:** The overall efficiency with which the reported data rate can be supported, reflected by the ratio of **NOMINAL TRAFFIC** versus the **NOMINAL POWER**.

**NOMINAL HEAT, BTU/HR:** The average amount of heat required to be dissipated over the course of a day (24 hours), taking into account hourly load variations. (1 watt = 3.412 BTU/hr)



# SPC-2/E, SPC-2C/E Introduction

## □ SPC-2/E and SPC-2C/E Reported Data definitions:

### Power Environment

Average RMS Voltage:

Average Power Factor:

	Usage Profile			Nominal			Heat BTU/hr
	Hours of Use per Day			Power watts	Traffic MBPS	Ratio MBPS/w	
	Heavy	Moderate	Idle				
Low Daily Usage:	0	8	16	6049.33	2185.53	0.36	20,640.91
Medium Daily Usage:	4	14	6	6134.88	5129.80	0.84	20,932.84
High Daily Usage:	18	6	0	6209.13	7512.21	1.21	21,186.16

<b>Composite Metrics:</b>			<input type="text" value="6,131.11"/>	<input type="text" value="4,942.51"/>	<input type="text" value="0.81"/>
<b>Annual Energy Use, kWh:</b>	<input type="text" value="53,708.55"/>				
<b>Energy Cost, \$/kWh:</b>	<input type="text" value="\$ 0.12"/>	<b>Annual Energy Cost, \$:</b>	<input type="text" value="\$ 6,445.03"/>		

**COMPOSITE METRICS:** The aggregated **NOMINAL POWER**, **NOMINAL TRAFFIC**, and **NOMINAL MBPS/W** for all three environments: **LOW**, **MEDIUM**, and **HIGH DAILY USAGE**.

**ANNUAL ENERGY USE, KWH:** An estimate of the average energy use across the three environments over the course of a year and computed as (**NOMINAL POWER** \* 24 \* 0.365).

**ENERGY COST, \$/KWH:** A standardized energy cost per kilowatt hour.

**ANNUAL ENERGY COST:** An estimate of the annual energy use across the three environments over the course of a year and computed as (**ANNUAL ENERGY USE** \* **ENERGY COST**).



# SPC-2/E, SPC-2C/E Introduction

- An example of SPC-2/E Large File Processing (LFP) Reported Data:
  - SPC-2C/E Reported Data is in an identical format.

### Power Environment

Average RMS Voltage:  Average Power Factor:

	Usage Profile			Power watts	Nominal		Heat BTU/hr
	Hours of Use per Day				Traffic MBPS	Ratio MBPS/w	
	Heavy	Moderate	Idle				
Low Daily Usage:	0	8	16	6068.44	2426.97	0.40	20,706.12
Medium Daily Usage:	4	14	6	6177.86	5690.73	0.92	21,079.46
High Daily Usage:	18	6	0	6266.34	8316.11	1.33	21,381.36

<b>Composite Metrics:</b>			<b>6,170.88</b>	<b>5,477.94</b>	<b>0.89</b>
Annual Energy Use, kWh:	54,056.88				
Energy Cost, \$/kWh:	\$ 0.12	Annual Energy Cost, \$:	<b>\$ 6,486.83</b>		

**HEAVY** SPC-2 Workload: 6,278.14W at a data rate of 8,661.17 MB/s.

**MODERATE** SPC-2 Workload: 6,230.91W at a data rate of 7,280.92 MB/s

**IDLE** SPC-2 Workload: 5,987.20W at data rate of zero (0).



# SPC-2/E, SPC-2C/E Introduction

- An example of SPC-2/E Large Database Query (LDQ) Reported Data:
  - SPC-2C/E Reported Data is in an identical format.

**Power Environment**

Average RMS Voltage:  Average Power Factor:

	Usage Profile			Power watts	Nominal		Heat BTU/hr
	Hours of Use per Day				Traffic MBPS	Ratio MBPS/w	
	Heavy	Moderate	Idle				
Low Daily Usage:	0	8	16	6065.96	2590.30	0.43	20,697.66
Medium Daily Usage:	4	14	6	6180.23	6235.22	1.01	21,087.55
High Daily Usage:	18	6	0	6294.69	9602.59	1.53	21,478.10
<b>Composite Metrics:</b>				6,180.29	6,142.70	0.99	
Annual Energy Use, kWh:	54,139.35						
Energy Cost, \$/kWh:	\$ 0.12			Annual Energy Cost, \$:	\$ 6,496.72		

**HEAVY** SPC-2 Workload: 6,318.43W at a data rate of 10,213.16 MB/s.

**MODERATE** SPC-2 Workload: 6,223.47W at a data rate of 7,770.90 MB/s

**IDLE** SPC-2 Workload: 5,987.20W at data rate of zero (0).



# SPC-2/E, SPC-2C/E Introduction

- An example of SPC-2/E Video on Demand Delivery (VOD) Reported Data:
  - SPC-2C/E Reported Data is in an identical format.

**Power Environment**

Average RMS Voltage: 209.96 Average Power Factor: 0.978

	Usage Profile			Power watts	Nominal		Heat BTU/hr
	Hours of Use per Day				Traffic MBPS	Ratio MBPS/w	
	Heavy	Moderate	Idle				
Low Daily Usage:	0	8	16	6013.59	1539.31	0.26	20,518.97
Medium Daily Usage:	4	14	6	6046.57	3463.45	0.57	20,631.50
High Daily Usage:	18	6	0	6066.36	4617.93	0.76	20,699.02

**Composite Metrics:** 6,042.17 3,206.90 0.53

Annual Energy Use, kWh: 52,929.42  
 Energy Cost, \$/kWh: \$ 0.12      Annual Energy Cost, \$: \$ 6,351.53

**HEAVY** SPC-2 Workload: 6,066.36W at a data rate of 4,617.93 MB/s.

**MODERATE** SPC-2 Workload: 6,066.36W at a data rate of 4,617.93 MB/s

**IDLE** SPC-2 Workload: 5,987.20W at data rate of zero (0).



## SPC-2/E, SPC-2C/E Introduction

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- SPC-2/E and SPC-2C/E Reported Data allows comparison of performance, price-performance, and energy use data singularly or in combinations.
  - A more informed purchase decision by end-users.
  - Expanded insight for vendors during the development and testing of new/updated products.